Water Quality Excerpts from the USFWS CVPIA Anadromous Fish Restoration Program

Sacramento River

PROBLEM

Water quality impacts on aquatic resources vary by location and season in response to variable streamflows and pollutant levels in point-source and non-point-source agricultural, municipal and industrial. Although largely unquantified, water quality impacts on fish populations in the Sacramento River and its tributaries include effects related to heavy metal pollution; high levels of suspended sediments; and elevated levels of nutrients, herbicides, and pesticides from agricultural drainage.

Heavy metal pollution caused by acid mine runoff principally from the Spring Creek basin continues to be a major source of water quality degradation and fish mortality in the upper Sacramento River. The Spring Creek Debris Dam was constructed by USBR in 1963 to control toxic discharges by coordinating releases with dilution flows from Shasta Reservoir and the Spring Creek Power Plant. Because of limited storage in Spring Creek Reservoir and availability of dilution flows, copper and zinc levels in downstream waters periodically exceed levels considered toxic to aquatic life (The Resources Agency 1989)

The US EPA listed the Spring Creek basin as an EPA Superfund cleanup site. EPA actions have reduced acid mine drainage and ongoing efforts are aimed at further remediation. EPA selected a neutralization treatment as an interim strategy that will virtually eliminate existing threats to the Sacramento River fishery and the Redding municipal water supply (Sacramento River Information Center 1993)

Recent studies indicate that striped bass larvae from the Sacramento River show a higher incidence of liver malformation than larvae from other areas of the estuary. Contamination of the Sacramento River increased substantially in the mid-1970s when application of rice pesticides increased (Herbold et al. 1992). Measured toxic concentration were sufficient to kill fish in sloughs draining rice fields, and estimated toxic concentrations for the Sacramento River during 1970-88 may have deleteriously affected striped bass larvae (Bailey 1992). Discharge of contaminated rice filled water coincides with striped bass spawning and may account for part of the decline in striped bass abundance. Pesticide application has correlated with young striped bass abundance, but direct relationships are inconclusive.

AFRP ACTIONS

Continue to maintain water *temperatures* at or below 56 degrees F from Keswick Dam to Bend Bridge to the extent controllable, consistent with the 1993 biological opinion for winter-run chinook salmon and with SWRCB Order 90-5.

Remedy water quality problems from toxic discharges associated with Iron Mountain Mine and water quality problems associated with metal sludges in Keswick Reservoir, consistent with the Comprehensive Environmental Response, Compensation, and Liability Act and the Clean Water Act.

Implement operational modifications *to Anderson-Cottonwood Irrigation District's* diversion dam to eliminate passage and stranding problems for chinook salmon and steelhead adults and early life stages and *toxic discharges* from the canal.

Identify and implement measures that will maintain mean daily water *temperatures* between 61 and 65 F for at least one month between April 1 and June 30 for American shad spawning.

Clear Creek

AFRP ACTION
Develop an erosion control and stream corridor protection program to prevent habitat degradation due to *sedimentation* and urbanization.

Cottonwood Creek

AFRP ACTION
Facilitate watershed protection and restoration to reduce water *temperatures* and *siltation* to improve holding, spawning, and rearing habitats for salmonids.

Battle Creek

AFRP ACTION
Evaluate alternatives for providing a *disease-safe water supply* to CNFH so that winter-, spring-, and fall-run chinook salmon and steelhead would have access to an additional 41 miles of Battle Creek habitat.

Elder Creek

AFRP ACTION
Work with Tehama County to develop an erosion control ordinance to minimize *sediment* input to Elder Creek.

Thomes Creek

AFRP ACTION

Identify and evaluate restoring *highly erodible* watershed areas.

Monitor water quality throughout the creek and identify limiting conditions for salmon.

Stony Creek

AFRP ACTION
Determine the feasibility of restoring anadromous salmonids by evaluating water releases from Black Butte Dam, water exchanges with the Tehama-Colusa Canal, interim and long-term water diversion solutions at Red Bluff Diversion Dam, **water quality improvements**, spawning gravel protection and restoration, riparian habitat protection and restoration, creek channel creation, and passage improvements water diversions.

Butte Creek

AFRP ACTIONS
Develop and enforce *land use plans that create buffer zones* between the creek and urban development.

Develop a watershed management program

Colusa Basin Drain (westside tributaries)

AFRP ACTION
Investigate the feasibility of restoring the access of anadromous fish to westside tributaries through development of defined migrational routes, sufficient flows and adequate water *temperatures.*

Miscellaneous small tributaries

AFRP ACTION
Encourage the restoration of small tributaries by evaluating the feasibility of screening or relocating diversions, switching to alternative sources of water for upstream diversions, restoring and maintaining a protected riparian strip, enforcing dumping ordinances, *removing toxic materials*, etc.

Feather River

AFRP ACTIONS
Develop and utilize a *temperature* model as a tool for river management.

Identify and attempt to maintain adequate flows and *temperatures* for white sturgeon and green sturgeon migration, spawning, incubation and rearing from February to May.

Identify and implement actions that maintain mean daily water *temperatures* between 61 F and 65 F for at least one month from April 1 to June 30 for American shad spawning.

Yuba River

AFRP ACTIONS
Operate reservoirs to provide adequate water *temperatures* for anadromous fish.

Identify and attempt to implement actions that will maintain mean daily water *temperatures* between 61 and 65 F for at least one month from April 1 to June 30 for American shad.

Bear River

AFRP ACTIONS
Provide adequate water *temperatures* for all life-stages of chinook salmon and steelhead.

Monitor water quality, particularly at agricultural return outfalls, and evaluate potential effects on anadromous fish.

Mokelumne

PROBLEM
Poor water quality conditions below Camanche Reservoir may adversely affect chinook salmon by inhibiting upstream migration of adult chinook to spawning areas. Water quality problems in the Mokelumne River have been associated with heavy metal pollution from Penn Mine, drought conditions, and Pardee and Comanche Reservoir operations. Recent fish kills at the Merced River Fish Facility were attributed to Camanche Reservoir discharges containing toxic levels of copper and zinc, low dissolved oxygen levels, and high concentrations of hydrogen sulfide. These conditions were associated with low inflows from Pardee Reservoir; record low reservoir levels; and hypolimnetic mixing, which may have mobilized sediments during the late summer and fall turnover of the reservoir.

AFRP ACTIONS
Maintain suitable water *temperatures* for all salmonid life stages.

Establish and enforce water quality standards to provide optimal water quality for all life history stages of salmonids.

Consumnes

AFRP ACTION
Rehabilitate damaged areas and remedy incompatible land practices to reduce *sedimentation* and instream water *temperatures.*

Merced

PROBLEM
Water temperatures below major dams on the San Joaquin River tributaries become unsuitable for chinook salmon rearing in May or June, causing high mortality of juvenile chinook salmon that have not emigrated.

AFRP ACTIONS
Provide additional law enforcement to reduce illegal take of salmon, stream alteration, and water pollution and to ensure adequate protection for juvenile salmon at pumps and diversions.

Identify and implement actions to provide suitable water *temperatures* for all life stages of chinook salmon: establish maximum temperature objectives of 56 from October 15 to February 15 for incubation and 65 from April 1 to May 31 for juvenile emigration.

Tuolumne River

PROBLEM
Generally water temperature below the dam become unsuitable for chinook salmon rearing in May or June, causing high mortality of juvenile chinook salmon that have not emigrated.

AFRP ACTIONS
Improve *watershed management* and restore and protect instream and riparian habitat, including consideration of restoring and replenishing spawning gravel.

Provide additional law enforcement to reduce illegal take of salmon, stream alteration, and water pollution and to ensure adequate protection for juvenile salmon at pumps and diversions

Identify and implement actions to provide suitable water *temperatures* for all life stages of chinook salmon: establish maximum temperature objectives of 56 from October 15 to February 15 for incubation and 65 from April 1 to May 31 for juvenile emigration.

Stanislaus River

AFRP ACTIONS
Improve *watershed management* and restore and protect instream and riparian habitat.

Provide additional law enforcement to reduce illegal take of salmon, stream alteration, and

water pollution and to ensure adequate screening of pumps and diversions.

Identify and implement actions to provide suitable water *temperatures* for all life stages of chinook salmon: establish maximum temperature objectives of 56 from October 15 to February 15 for incubation and 65 from April 1 to May 31 for juvenile emigration.

Evaluate use of the Stanislaus River by American shad and consider increasing flows and maintaining mean daily water *temperatures* between 61 F and 65 F from April to June when hydrologic conditions are adequate to minimize adverse effects to water supply operations and in a manner consistent with actions to protect chinook salmon.

Mainstem San Joaquin River

PROBLEM
Low dissolved oxygen levels (less than 5 ppm) and high water temperatures (greater than 66 F) in the San Joaquin River near Stockton delayed or blocked the migration of adult chinook salmon during the 1960s (Hallock et as. 1970). Since 1964, fall migrations have been reduced by improved wastewater treatment and installation of a physical barrier at the head of Old River in dry years to direct most of the San Joaquin flows down the main channel past Stockton. Despite these efforts, low dissolved oxygen levels recurred during recent drought conditions. Remedial measures that are currently proposed include increasing tributary outflow, evaluating and monitoring dredging activity in the Delta, and further evaluating the fall barrier at Old River (The Resources Agency 1992).

Selenium in agricultural drainage water poses a potential risk to juvenile chinook salmon in the main San Joaquin River. Selenium is directly toxic to fish at elevated levels in the water column and through bioaccumulation in body tissues. Growth and survival of juvenile chinook salmon are adversely affected by exposure to dissolved and dietary selenium, but harmful levels have not been detected in the major San Joaquin River and tributary rearing areas (DFG 1978b).

Declining streamflow during the spring emigration period of fall-run chinook salmon coincides with rising air temperatures and increased agricultural return flows to the San Joaquin River, often resulting in deleterious water temperatures along much of the emigration route in the lower San Joaquin River. In May, water temperatures in the San Joaquin River near Vernalis often reach chronic stress levels (greater than 67.6 F) at flows of 5,000 cfs or less. Under these conditions, up to half the production of San Joaquin River chinook salmon can be subjected to harmful water temperatures. (DFG 1978b.)

Approximately 40% of the striped bass populations spawns in the Delta, generally in the lower San Joaquin River, from Venice Island downstream to Antioch. Salinity in the western Delta affects the spawning distribution in the Delta (DFG 1987). The lowest salinity occurs immediately downstream of the confluence of the San Joaquin and Mokelumne rivers, where fresh water from the Mokelumne and Sacramento rivers enters the San Joaquin River. To the east, the San Joaquin River discharges water contaminated with salty agricultural drainage. To the west, seawater intrusion increases. Adult striped bass react to increasing salinity from agricultural salts in the San Joaquin River and do not migrate through salinity exceeding 550µS EC (RADTKE 1966, DFG 1987).

Survival of adult striped bass may be affected by toxic materials entering the Sacramento-San Joaquin estuary from agricultural runoff, discharge of industrial and municipal waste, and runoff from non-point sources (i.e., stormwater runoff). Adult striped bass tissues contain concentration of toxics exceeding levels recommended for human consumption; however, data prior to the striped bass decline after 1970 are unavailable for comparison (Herbold et al. 1992). Relative to striped bass on the Atlantic Coast and in other estuaries, striped bass from the Sacramento-San Joaquin estuary appear to be in poor health and often have open lesions (reactions to parasite infection) (Brown 1987).

Every year, during May and June, hundreds to thousands of adult striped bass die and wash up along the shoreline of the estuary *Brown 1992). The highest density of dead adults is found in Carquinez Strait. Livers from dead striped bass were contaminated with higher concentrations of toxic materials than the livers of healthy fish taken from the Delta. A causative factor for the die-off has not been identified, but the relatively high concentration of toxic materials may contribute to factors resulting in the mortality.

The number of viable eggs is directly affected by contaminant levels in prespawning females, causing resorption of eggs or production of abnormal embryos (Brown 1987, DFG 1987). Analysis has not shown strong relationships between reproductive condition, parasite burdens, and pollutant concentrations. Female striped bass in the estuary, however, are less fecund than female bass from other estuaries. Reduced fecundity appears to be related to the effects of toxic materials, but the extent of reduced fecundity is unknown.

Egg and larval sampling in the sloughs leading to the North Bay Aqueduct indicate that striped bass abundance has increased (Herrgesell 1993).

AFRP ACTIONS

Prohibit the *dredging* of the Stockton ship channel during critical periods.

Identify and implement actions to improve *watershed management* to restore and protect instream and riparian habitat.

Identify and implement actions to maintain suitable water *temperatures* or minimize length of exposure to unsuitable water temperatures for all life stages of chinook salmon in the San Joaquin River and Delta.

Identify and attempt to implement actions that will maintain mean daily water *temperatures* between 61 F and 65 F for at least one month from April to June 30 form American shad, when

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hydrologic conditions are adequate to minimize adverse effects to water supply operations and in a manner consistent with actions to protect chinook salmon.

Delta

PROBLEM
The Delta chinook salmon smolt mortality model includes three predictive relationships describing changes in smolt mortality as a linear function of water temperature for three major Delta reaches. Smolt survival appears to decline at temperatures above 60 F, indicating that sublethal effects may be occurring at relatively low water temperatures in the Delta.

The decline of the striped bass population in the Sacramento-San Joaquin estuary has generated substantial evaluation of casual factors. Factors that my have contributed to increased mortality after 1967 include the same factors that affected mortality before 1967 (i.e., fishing, entrainment in diversions, exposure to toxic materials, and habitat loss). Additional factors that affect mortality include reduced Delta inflow and outflow, altered Delta flow patterns, dredging and spoil disposal, diseases and parasites, and introduction of exotic species. Annual adult striped bass mortality rates increased from approximately 40% in the early 1970s to 53% in recent years (DFG 1987). The cause of increased adult mortality rates may be attributed to habitat loss, increased levels of toxic materials, sport and illegal fishing, and other factors. Reduced reproduction results from fewer fertile eggs being produced by the population each year. Factors that may have affected the number of fertile eggs produced include factors affecting the abundance, size, and health of female striped bass. Mortality rates determine the abundance of female bass. Factors affecting size and health of female striped bass include accumulation of toxic materials by the female bass, diseases and parasites, and reduced food availability.

Larval striped bass survival may have been reduced by the toxic effects of insecticides, herbicides, trace elements, and other toxic materials that have entered the estuary from agricultural runoff and municipal and industrial discharge. Toxic material can affect larval bass directly and indirectly, causing mortality within a short period (days) or adversely affecting growth and development, which limit the chances for survival (Brown 1987).

Although the decline in striped bass abundance that has occurred over the last 20 years is not attributable to toxic material alone, toxics may have substantially reduced survival of striped bass compared to other estuaries. The issue of toxic material needs to be addressed in much greater detail to determine the effect on striped bass abundance.

All life stages of American shad may be affected by toxic materials entering the Sacramento-San Joaquin River system from agricultural runoff, discharge of industrial and municipal waste, and urban runoff. In the Delta, pollutants of particular concern are trace elements (e.g., selenium, copper, cadmium and chromium) and agricultural chemicals and their derivatives, which are used extensively in the Central Valley.

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Although no specific information is available on how toxic materials are affecting shad populations in the rivers or Delta, the effects of toxics on adult shad may be similar to know effects on other Delta fish species. For instance, toxics exceeding levels considered safe for human consumption have been found in tissue samples of adult striped bass and appear to reduce fecundity in female striped bass. Although toxic materials likely have an adverse affect on adult shad, no evidence exists to suggest that these materials are causing a decline in shad abundance. Toxic materials may affect adults either directly or indirectly, thereby reducing reproductive success and survival.

One of the complicating factors in understanding the effects of toxics on ecological processes in the estuary is the complex distribution of "hot spots" both spatially and temporally (Herbold et al. 1992). These hot spots may cause adults to avoid biologically important habitat or alter movements.

Although shad spawn when flows are typically high and pollutant concentrations are probably relatively low, localized populations of young shad and eggs may be disproportionately affected by pollutants if developing eggs and larvae encounter discharges containing high pollutant concentrations. Developing eggs and larvae in the vicinity of these discharges may experience poor development, reduced growth rates, and increased mortality, but specific data are unavailable to ascertain the importance of toxic materials in determining shad abundance.

AFRP ACTIONS

Increase public education efforts and hazardous waste pick-ups to minimize water quality impacts associated with the use of pesticides and other hazardous materials.

Evaluate feasibility of Delta channel barriers and other technologies to improve water quality and to guide migrating fish.

Evaluate land retirement as a means of improving water quality and riparian and rearing habitats, and reducing the number of diversions in the Delta.

Evaluate opportunities to develop channel buffer zones to enhance riparian areas and reduce *sedimentation.*

Systemwide

PROBLEM

The influence of water pollution on sturgeon is not well documented. Sturgeon tissue has been found to contain PCBs, organochlorines, mercury, selenium, and dioxins (PSMFC 1992). Egg tissues can also contain toxins, which could reduce reproductive potential (Doroshov 1990). Turbidity can affect the adhesiveness of eggs, which could displace eggs to less-than-optimum habitats during incubation.

AFRP ACTION

Evaluate effects of trace elements and organic contaminants, especially selenium and PCBs, on the health of adult white sturgeon and green sturgeon, the viability of their gametes, and development of their offspring.

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